An Unrecognized Source of PCB Contamination in Schools and Other Buildings

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An investigation of 24 buildings in the Greater Boston Area revealed that one-third (8 of 24) contained caulking materials with polychlorinated biphenyl (PCB) content exceeding 50 ppm by weight, which is the U.S. Environmental Protection Agency (U.S. EPA) specified limit above which this material is considered to be PCB bulk product waste. These buildings included schools and other public buildings. In a university building where similar levels of PCB were found in caulking material, PCB levels in indoor air ranged from 111 to 393 ng/m^3; and in dust taken from the building ventilation system, < 1 ppm to 81 ppm. In this building, the U.S. EPA mandated requirements for the removal and disposal of the PCB bulk product waste as well as for confirmatory sampling to ensure that the interior and exterior of the building were decontaminated. Although U.S. EPA regulations under the Toxic Substances Control Act stipulate procedures by which PCB-contaminated materials must be handled and disposed, the regulations apparently do not require that materials such as caulking be tested to determine its PCB content. This limited investigation strongly suggests that were this testing done, many buildings would be found to contain high levels of PCBs in the building materials and potentially in the building environment. The presence of PCBs in schools is of particular concern given evidence suggesting that PCBs are developmental toxins. ***Key words:*** **carcinogen, developmental toxin, environmental exposure, PCB, public buildings, remediation, schools.** ***Environ Health Perspect*** **112:1051–1053 (2004). doi:10.1289/ehp.6912 available via *http://dx.doi.org/* [Online 25 March 2004]**

Polychlorinated biphenyls (PCBs) are a set of persistent organic chemicals that are known or suspected to cause a wide range of health effects. There is clear evidence that PCBs cause cancer in animals, and they are considered probable human carcinogens [U.S. Environmental Protection Agency (EPA) 1996]. Human and animal data provide evidence that PCBs have significant toxic effects, including effects on the immune system, the reproductive system, the nervous system, and the endocrine system. Production of PCBs was halted in the United States in 1977; however, their persistence in the environment and tendency to bioaccumulate have been well documented [Agency for Toxic Substances and Disease Registry (ATSDR) 2000].

Although the principal use of PCBs was in "closed systems," such as electrical transformers, capacitors, and other equipment where the PCBs were encased, they were also used in a range of "open system" products, including building materials, from which they may seep into their surrounding environment. Among these building materials was the caulking used to seal joints between masonry units and around windows. This caulking contained PCBs as plasticizers in two-part polysulfide polymer systems. The ATSDR identified the specific PCB compound Aroclor 1254 as an ingredient in caulking and sealing compounds. Aroclor 1254 is the trade name for a mixture of chlorinated biphenyls with average chlorine content of 54%. Its composition is reported to be approximately 59–71% (by weight) pentachlorobiphenyl, 22–27% hexachlorobiphenyl, and 5–10% tetrachlorobiphenyl (ATSDR 2000).

PCBs in Building Materials

Buildings that were constructed or refurbished before 1977 may still contain caulking with elevated levels of PCBs. Caulking has been analyzed only rarely for PCB content; therefore, it is poorly recognized as a hazard. There have been few studies of the extent to which PCBs from caulking and sealing material may cause exposures to building occupants, workers removing or maintaining the material, or general environmental contamination. Several investigations in Germany, Sweden, and Finland have demonstrated relationships between PCBs in sealants (caulking) and levels in indoor air and settled dust, as well as in soil around the foundations of buildings containing these materials (Balfanz et al. 1993; Burkhardt et al. 1990; Corner et al. 2002; Fromme et al. 1996; Pyy and Lyly 1998). An investigation of teacher exposures to PCBs in German schools containing PCBs in building caulking material found moderate elevations of blood levels of PCB-28 and PCB-101 among teachers in some schools (Gabrio et al. 2000). The impact of these elevations is modest compared with those associated with eating contaminated fish, for example. Comparisons of outdoor and indoor PCB concentrations in air found that the air in buildings significantly exceeds outdoor air by factors ranging from 1.8 to 180, suggesting indoor sources of PCBs. The potential for exposure by inhalation and ingestion of PCB-containing dust, inhalation of vapor, and dermal contact with PCBs on contaminated surfaces has not been fully characterized. The overall significance of the contribution of inhalation to total PCB burden was estimated to range from 6 to 64% and was predicted to rise if the PCB content in food continues to fall (Currado and Harrad 2000).

In the United States, a recent investigation documented elevated PCB levels in the air and dust in a university office building. PCB levels inside the university building ranged from 111 to 393 ng/m^3 in indoor air and from < 1 ppm to 81 ppm in dust taken from the ventilation system. PCB levels exceeding the allowable limit of 50 ppm set by the U.S. EPA were found in caulking material (caulking contained PCB concentrations up to 33,000 ppm, which is 600 times the U.S. EPA limit of 50 ppm, above which material is required to be regulated as PCB bulk product waste), gasket material around windows (1.1–4,300 ppm), foamboard insulation (below reportable level of 310 ppm), and components of the building ventilation system (3.7–63 ppm) (Coghlan et al. 2002). The PCB was identified as Aroclor 1254, which is the PCB formulation reported to be included in caulking and sealing materials (ATSDR 2000). The U.S. EPA considers materials exceeding PCB content of 50 ppm that were not specifically authorized for use by U.S. EPA to be "unauthorized-use" nonliquid PCB products that require removal and decontamination (U.S. EPA 1998a). PCB bulk product waste is defined in 40CFR761.3 (U.S. EPA 1998a) as

> waste derived from manufactured products containing PCBs in a non-liquid state, at any concentration where the concentration at the time of designation for disposal was ≥ 50 ppm PCBs. . . . PCB bulk product waste includes, but is not limited to: Non-liquid bulk wastes or debris from the demolition of buildings and other man-made structures manufactured, coated, or serviced with PCBs.

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In the case of the PCB-contaminated university building, the U.S. EPA mandated a cleanup program that included removal of window components from the building, abatement of caulking residues from window openings, removal of PCB-containing caulking from window frames, removal and replacement of unit ventilators, removal of PCB-containing foamboard, and duct and space cleaning and restoration. Clearance criteria for declaring the decontamination complete as determined by the U.S. EPA project manager included air samples with < 1,000 ng/m^3 PCBs, surface wipe samples with < 10,000 ng/100 cm^2, and remaining porous building components (brick and concrete block) < 1 ppm PCB by weight (Chang et al. 2002). Compliance with this abatement plan required removal of porous masonry material in some parts of the building, because PCBs had permeated up to 2 inches beyond the surface.

Survey of PCB Content in Caulking

Members of the International Union of Bricklayers and Allied Craft Workers (BAC) recognized that the use of the PCB-containing caulking material of the type responsible for the contamination of this university building was a common construction practice in the 1970s. They reported that these formulations changed during the late 1970s, possibly corresponding to the elimination of PCBs mandated by the U.S. EPA in 1977 (Weymouth G, personal communication). These workers recalled numerous symptoms they associated with the use of the PCB-containing caulking, including itching, rash, and blisterlike sores on the skin, and dry throat. Because they used a number of other materials, including toluene, the attribution of their symptoms to PCB exposure is not certain; however, these dermal symptoms have been reported in humans occupationally exposed to PCBs (ATSDR 2000). The workers verified that although the installation of PCB-containing caulking ended in the late 1970s, this material remained in place in these buildings. Because this material is now nearly 30 years old, construction workers are now removing deteriorated PCB-containing caulking from many buildings. This removal is performed without testing the caulking to determine its PCB content, and workers generally do not use protective equipment. They use manual and power tools to remove the material from building walls, and the caulking is disposed of as general demolition waste (Weymouth G, personal communication).

This investigation was conducted to determine whether PCBs were still present in a set of buildings where experienced Pointer Caulker Cleaner craft workers of the BAC remembered installing polysulfide caulking materials containing PCBs in the 1970s. Measurement of PCBs inside the buildings and of exposures to building occupants or construction workers removing caulking materials from these buildings was beyond the scope of this preliminary investigation; however, it is addressed in recommendations for further studies.

To estimate the PCB content of caulking in a set of buildings in the Greater Boston Area, small (~ 10 g) samples were taken from 24 buildings in which experienced BAC workers remembered installing caulking in the 1970s. The sampled buildings included schools, churches, museums, and office buildings. These samples were collected in August and September 2003. In some buildings, reconstruction projects were underway and the old caulking was actively being removed. In other buildings, the old caulking appeared to have already been replaced, and in still others the caulking from the 1970s was deteriorated and was falling from the building joints. Samples were collected and analyzed in accordance with U.S. EPA method SW846 8082A (U.S. EPA 1998b).

Results

Of the 24 buildings sampled, 13 contained caulking material in which detectable levels of PCBs were measured. Of these 13, 8 buildings contained caulking that exceeded the 50 ppm U.S. EPA criteria, in some cases by a factor of nearly 1,000 (range, 70.5–36,200 ppm; mean, 15,645 ppm). In seven of these buildings, the laboratory identified the PCB as Aroclor 1254, and Aroclor 1260 was found in the remaining sample. The buildings where elevated PCB levels in caulking were found include schools, university buildings, and other public buildings (Table 1).

Discussion

The similarity between these results and the university building in which the PCB-containing caulking caused extensive contamination suggests that at least some of these buildings should be fully evaluated for PCB contamination. In fact, although the U.S. EPA regulations (40CFR761; U.S. EPA 1998a) specify the procedures by which PCB-containing materials must be handled and disposed of, there is apparently no requirement that materials such as caulking must be analyzed for PCB content. This limited investigation of buildings in the greater Boston area suggests that there is a very substantial likelihood that buildings may contain PCB-laden caulking at levels that triggered comprehensive remediation measures mandated by U.S. EPA. In particular, buildings constructed of masonry—including schools, hospitals, water and sewerage treatment plants, power plants, hospitals, and other public buildings constructed or renovated during the 1960s or 1970s—may contain these types of caulking and sealing materials.

In cases where PCB-containing caulking and materials such as masonry are removed, it is essential that comprehensive control programs be implemented to prevent further contamination. Construction projects to remove PCB-containing sealants (caulking) from buildings in Sweden and Finland have demonstrated that carefully controlled methods must be used to protect the remediation workers and to prevent further environmental contamination (Kontsas et al. 2004; Priha 2003; Sundahl et al. 1999). Workers removing PCB-containing sealant between concrete blocks in a Swedish building found that they could remove 99% of the PCB by cutting and grinding away the caulking material, as well as a few millimeters of the concrete surrounding the caulked joints (Sundahl et al. 1999). These investigators concluded that they prevented significant increases of PCB in the building environment by using tools connected to a high-capacity vacuum cleaner to capture the dust produced by the removal processes (Sundahl et al. 1999).

In a study of PCB sealant removal from prefabricated concrete buildings in Finland, workers were found to have PCB concentrations in blood approximately three times higher than normal population levels, despite the use of exhaust-ventilated tools and protective equipment including respirators, gloves, and coveralls (Kontsas et al. 2004; Priha 2003).

Table 1. Results of sample analysis of 24 buildings.

Building type	PCB content (ppm by mass)[a]
Government office, mixed use	35,600
Government office	25.2
Office building	ND[b]
Subsidized housing	ND
Subsidized housing	ND
Elderly housing	ND
Elderly housing	ND
University student housing	36,200
University dormitory	70.5
University dormitory	1.68
University classrooms and offices	26,400
Elementary school	7,740
Middle school	5,010
High school	5,970
High school	ND
High school	ND
Community college	19.3
Church offices	2.14
Synagogue	8,240
Hospital	ND
Hospital	ND
Museum	0.56
Hotel	ND
Police station	ND

[a]All samples except for the sample from the governmental office/mixed use building were identified as Aroclor 1254; that sample was identified as Aroclor 1260. [b]Samples reported as not detected (ND) contained PCB below the reporting limit, which ranged from 114 to 455 μg/kg (0.114–0.455 ppm).

Our survey, although limited by the small sample size (24 buildings) and the nonrandom selection of sites, strongly suggests that caulking installed before the ban in 1977 may pose a significant public health hazard. PCB-contaminated caulking is of particular concern given the proven potential for exposure among building occupants and among workers who remove the material. The finding that of the eight buildings exceeding the 50 ppm U.S. EPA limit, two were student housing and four were schools is a concern. Although most studies investigating the developmental effects of PCBs have found prenatal exposure to be more important than postnatal exposure, it is not known whether school-age children have different susceptibility to the health effects of PCBs compared with adults. In its toxicologic review, the ATSDR (2000) concluded that

> Younger children may be particularly vulnerable to PCBs because, compared to adults, they are growing more rapidly and generally have lower and distinct profiles of biotransformation enzymes, as well as much smaller fat depots for sequestering the lipophilic PCBs.

Recommendation

A random probability-based survey should be conducted of schools, hospitals, and other masonry buildings constructed or renovated during the time when PCB-containing caulking was in use. Information from the manufacturers and suppliers of these caulking materials would help focus this survey by identifying the period of production and use of these materials, as well as their geographic distribution in the United States. In cases where the presence of these materials is considered likely, caulking should be routinely analyzed for PCBs and contaminated materials managed appropriately to reduce the potentially significant health risks resulting from PCB exposure.

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